

REMARKS

Applicants have amended their specification in light of objections to the drawings in Items 1-3 on pages 2 and 3 of the Office Action mailed February 22, 2007. Specifically, Applicants have amended line 5 on page 10 to use reference character "18" for the high-frequency power supply, consistent with the description in the first paragraph on page 12 of Applicants' specification. In view of this amendment to the specification, it is respectfully submitted that the objection to the drawings as set forth in Item 1 on page 2 of the Office Action mailed February 22, 2007, is moot. In this regard, Applicants note that the reference character "19" was used in the specification to designate both a high frequency power supply and a matching circuit, and wonder why, based upon an error in the specification, the drawings are objected to, especially since the specification on page 12 refers to high-frequency power supply "18". In any event, in view of amendment of page 10 of the specification, this objection to the drawings in Item 1 on page 2 of the Office Action mailed February 22, 2007, is moot.

Applicants have amended the paragraph bridging pages 29 and 30 of their specification to use reference character "113" for the deposits, and to use reference character "305" for the entrance window; and have amended Figs. 5 and 6, in the enclosed Replacement Sheet, to show impurities designated by reference character "113" on entrance window 110. In view of these amendments to the specification and to Figs. 5 and 6, it is respectfully submitted that the objections to the drawings in Items 2 and 3 on pages 2 and 3 of the Office Action mailed February 22, 2007, are moot.

Applicants have amended their claims in order to further clarify the definition of various aspects of the present invention. Specifically, Applicants have amended

claim 1 to recite a method for cleaning processing a plasma processing apparatus; to recite that the processing chamber has its interior evacuated (deleting recitation of “capable of having” its interior evacuated); and to recite a step of removing an aluminum fluoride deposit adhered to the interior of the processing chamber by applying the high-frequency power to the Si wafer. In light of amendments to claim 1, claim 2 has been cancelled without prejudice or disclaimer.

Applicants have amended claim 3 to recite a method for cleaning processing a plasma processing apparatus for generating a plasma in a vacuum container of the plasma processing apparatus. Applicants have further amended claim 3 to recite that a period for cleaning an aluminum fluoride deposit in the vacuum container by generating a plasma is provided; and to recite that the plasma contains chlorine gas and hydrobromic gas to create a gas-phase reaction product. In light of amendments to claim 3, claims 5 and 6 have been cancelled without prejudice or disclaimer. In addition, claims 4 and 7 have been cancelled without prejudice or disclaimer. Claims 8-10, 13 and 14 have been amended consistent with amendments to claim 3, including to recite the method for cleaning processing a plasma processing apparatus. In addition, dependencies of claims 8-10 and 14 have been amended, each claim now being dependent on claim 3. In addition, claims 11 and 12 have been cancelled without prejudice or disclaimer.

Moreover, Applicants are adding new claims 15-17 to the application. Claim 15, dependent on claim 3, recites that the plasma containing chlorine gas and hydrobromic gas additionally contains Si, to create the gas phase reaction product. Claims 16 and 17, each dependent on claim 3, respectively recites that a portion of material constituting the vacuum container includes Si; and recites that the plasma containing chlorine gas and hydrobromic gas, used in the cleaning processing,

additionally contains SiCl_4 gas. In connection with claims 15-17, note, for example, previously considered claims 4, 11 and 12, respectively.

Applicants respectfully traverse the rejection of their claims under 35 USC 112, second paragraph, as being indefinite, set forth on pages 3 and 4 of the Office Action mailed February 22, 2007, particularly insofar as this rejection is applicable to the claims as presently amended. Thus, the terms that the Examiner contends are indefinite, set forth in the first three lines on page 4 of this Office Action mailed February 22, 2007, have been deleted from the present claims, and thus this basis for rejection of the claims as indefinite is moot.

Applicants respectfully traverse the conclusion by the Examiner that claims 1-14 are "incomplete for omitting essential steps", set forth in Item 6 on page 4 of the Office Action mailed February 22, 2007. Contrary to the conclusion by the Examiner, it is respectfully submitted that the present claims recite necessary steps for the "method for cleaning processing", as in all of the present claims, and thus do not omit essential steps.

The Examiner contends that the omitted steps are the steps of processing plasma processing apparatus and steps of processing a substrate placed on a substrate holder. However, emphasizing that the present claims recite a method for cleaning processing a plasma processing apparatus, it is respectfully submitted that the claims need not recite processing of a substrate placed on a substrate holder. Claim 3 has been amended to recite that the plasma processing apparatus is used for generating a plasma in the vacuum container of the apparatus and processing substrate placed on a holder in the container. Moreover, it is respectfully submitted that the steps as in the present claims define processing the plasma processing

apparatus by cleaning, thereby being consistent with the subject matter of the claims as a whole.

Contentions by the Examiner in Item 7 on page 4 of the Office Action mailed February 22, 2007, are noted. In view of present amendments to the claims, it is respectfully submitted that such contentions therein are moot.

Applicants respectfully submit that all claims presented for consideration by the Examiner patentably distinguish over the documents applied by the Examiner in rejecting claims in the Office Action mailed February 22, 2007, that is, the teachings of the Japanese patent documents to Fukuyama, et al., No. 09-171999 (JP '999), to Hasegawa, No. 07-130706 (JP '706), to Yan, et al., No. 09-186143 (JP '143), to Soda, No. 2001-308068 (JP '068), to Nawata, et al., No. 2000-012515 (JP '515), and to Kitsunia, et al., No. 11-186226 (JP '226), under the provisions of 35 USC 103.

It is respectfully submitted that these documents as applied by the Examiner would have neither taught nor would have suggested such a method for cleaning processing as in the present claims, including, inter alia, mounting a Si wafer on an electrode for holding the object to be processed, and introducing hydrobromic gas and chlorine gas into the processing chamber and generating plasma, and removing an aluminum fluoride deposit adhered to the processing chamber by applying high-frequency power to the Si wafer. See claim 1.

In addition, it is respectfully submitted that the applied documents would have neither taught nor would have suggested such a method for cleaning processing a plasma processing chamber, including providing a period for cleaning an aluminum fluoride deposit in the vacuum container by generating plasma containing chlorine gas and hydrobromic gas to create a gas-phase reaction product. See claim 3.

Moreover, it is respectfully submitted that these applied documents would have neither taught nor would have suggested such method as in the present claims, having features as discussed previously in connection with claim 3, and, additionally, wherein the plasma containing chlorine gas and hydrobromic gas additionally contains Si. See claim 15.

Furthermore, it is respectfully submitted that the teachings of the applied documents would have neither disclosed nor would have suggested such cleaning processing method as in the present claims, having features as discussed previously in connection with, e.g., claims 3 and 15, and further including features as in the remaining dependent claims in the application, such as (but not limited) wherein a Si wafer with no patterns printed thereon is placed on the substrate holder, and high-frequency power is applied to the Si wafer through the substrate holder (see claim 8), in particular, wherein the high-frequency power applied is that set forth in claim 9; and/or wherein a ratio of an area of an earth to the area of an inner wall of the vacuum container in contact with plasma is 40% or more (see claim 10); and/or wherein N_2 , CO, CO_2 , H_2 or SO_2 is supplied simultaneously with the chlorine gas and the hydrobromic gas contained in the plasma (see claim 13); and/or wherein a period for generating plasma containing SF_6 prior to the period for generating plasma with the chlorine gas and hydrobromic gas is provided (see claim 14); and/or wherein a portion of material constituting the vacuum container includes Si (see claim 16); and/or wherein the plasma containing chlorine gas and hydrobromic gas additionally contains $SiCl_4$ gas (see claim 17).

The present invention relates to a method for cleaning a plasma processing apparatus, particularly useful in connection with cleaning a vacuum chamber having an aluminum fluoride deposit therein. Such deposit can cause problems if not

cleaned, in that such deposit builds up and can affect the plasma, and can also flake off and deposit on the substrate being processed, causing defective products and thus undesirably reducing yield.

It has been known that when a gas containing fluorine is used during plasma processing, aluminum fluoride is generated, which is a stable compound having low vapor pressure and which cannot be removed easily. Various methods for removing aluminum fluoride have been proposed. One method uses Cl_2 gas to decompose AlF_3 into AlCl_3 , and another method proposed decomposing and removing AlF_3 using H_2O and Cl_2 . As for these previously proposed cleaning methods, note the paragraph bridging pages 5 and 6 of Applicants' specification.

However, recently materials of the wafers, and gasses used in the plasma processing, have diversified, and the problem of deposits that cannot be removed by conventional plasma cleaning methods have become more significant. Note the last full paragraph on page 6 of Applicants' specification. Therefore, a more effective method for cleaning the reaction chamber is required, for enhancing throughput.

Against this background, Applicants provide a method wherein contaminants, such as deposits, in the vacuum processing chamber, can be safely and effectively removed, in a short time, thereby avoiding reductions in throughput. Applicants have found that by forming a plasma including hydrobromic gas and chlorine gas, such plasma can be used to remove aluminum fluoride deposits adhered to the interior of the processing chamber, effectively and in a short time. Note especially Embodiment 1 on pages 9-14 of Applicants' specification.

Applicants have further found that by including Si in the plasma containing chlorine gas and hydrobromic gas, a further improvement of speed in removing aluminum fluoride is achieved. Note Embodiment 4 on pages 22-27 of Applicants'

specification. Note especially Table 1 on page 23, and the discussion in connection therewith in the paragraph bridging pages 23 and 24, of Applicants' specification; see also Embodiment 2 on pages 16 and 17.

In addition, Applicants have found that with various processing, carbon deposits may occur in the processing chamber; and that such carbon deposits can be removed effectively and efficiently, by generating plasma containing SF₆ prior to generating the plasma with the chlorine and hydrobromic gasses.

JP '999 discloses a plasma cleaning treatment, subsequent to etching, with a mixed gas plasma of BCl₃ and Cl₂, a laminated structure film which uses an organic film and which contains, inter alia, a barrier metal. This patent document discloses that in order to remove the reaction product of the etching treatment, the inside of the etching treatment chamber is plasma-treated with H₂O gas, and then the inside of the etching treatment chamber is plasma-treated with a gas containing chlorine. After that, the inside of the etching treatment chamber is plasma-treated additionally with O₂ gas.

It is respectfully submitted that this reference does not disclose, nor would have suggested, such method as in the present claims, including wherein the plasma contains hydrobromic gas together with chlorine gas, and advantages achieved due thereto.

As will be shown in the following, taking the teachings of the references as applied by the Examiner, these references do not disclose, nor would have suggested, the plasma with the combination of chlorine gas and hydrobromic gas.

Thus, JP '515 discloses a plasma cleaning method for microwave plasma etching apparatuses, wherein an etching chamber is cleaned with a mixed gas of BCl₃ with Cl₂ after ending the etching.

JP '706 discloses a method for cleaning semiconductor manufacturing apparatuses, wherein cleaning is carried out in the presence of a Cl_2 gas, plasma treatment for cleaning being conducted with the Cl_2 gas, a reaction product made of AlF_3 being changed into an AlCl_3 gas that has a high vapor pressure, which gas is vaporized easily and discharged easily.

JP '068 discloses a method of cleaning a chamber of an etching apparatus, which chamber has AlF_3 deposited on an inner wall thereof. The cleaning includes a first step of performing H_2O plasma processing and following the first step with a second step of performing Cl_2 plasma processing.

Even assuming, arguendo, that the teachings of either of JP '706 or JP '068 were properly combinable with the teachings of either of JP '515 or JP '226, such combined teachings would have neither disclosed nor would have suggested the presently claimed invention including use of the plasma of the mixed gas of chlorine gas and hydrobromic gas, and/or additionally including Si in such gas, or including the various techniques as in the present claims for including Si, and/or other features of the present invention as set forth in the foregoing, and advantages thereof.

It is respectfully submitted that the additional teachings of JP '143 would not have rectified the deficiencies of JP '515 or JP '226, in combination with JP '706 or JP '068, such that the present invention as a whole would have been obvious to one of ordinary skill in the art.

JP '143 discloses a method and apparatus for cleaning by-products off plasma chamber surfaces, including a single cleaning step which involves (a) an operation of introducing a plasma reactive gas mixture containing halogen, composed of a gas containing fluorine of an equal or larger amount and containing chlorine of an equal or smaller amount, into a vacuum plasma process chamber

virtually free from species containing atomic oxygen; (b) an operation of producing the plasma of the above-mentioned reactive gas; and (c) an operation of bringing the above-mentioned plasma and/or the produced species into contact with accumulated residue sticking to the inside surface of a chamber.

Even assuming, arguendo, that the teachings of JP '143 were properly combinable with the teachings of other references as applied by the Examiner, such combined teachings would have neither disclosed nor would have suggested the presently claimed invention, including, inter alia, the cleaning processing utilizing the plasma containing the chlorine and hydrobromic gasses, much less the additional use of Si, and advantages thereof as in the present invention; and/or the other features of the present invention as discussed previously, and advantages thereof.

In view of the foregoing comments and amendments, reconsideration and allowance of all claims presently in the application are respectfully requested.

To the extent necessary, Applicants hereby petition for an extension of time under 37 CFR 1.136. Kindly charge any shortage of fees due in connection with the filing of this paper, including any extension of time fees, to the Deposit Account of Antonelli, Terry, Stout & Kraus, LLP, Account No. 01-2135 (case 648.43608X00), and please credit any overpayments to such Deposit Account.

Respectfully submitted,

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